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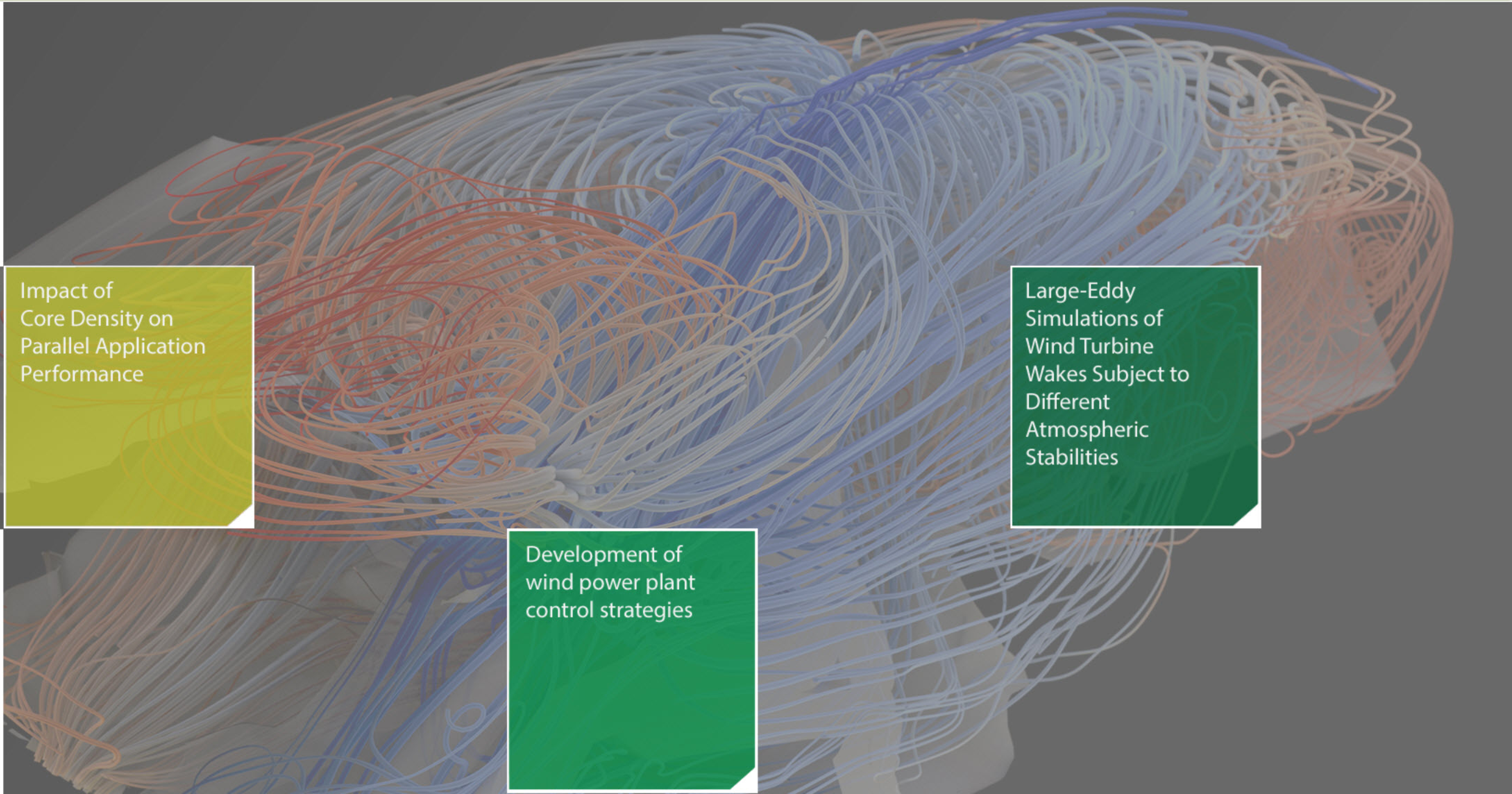

Impact of Core Density on Parallel Application Performance

Large-Eddy Simulations of Wind Turbine Wakes Subject to Different Atmospheric Stabilities

Development of wind power plant control strategies

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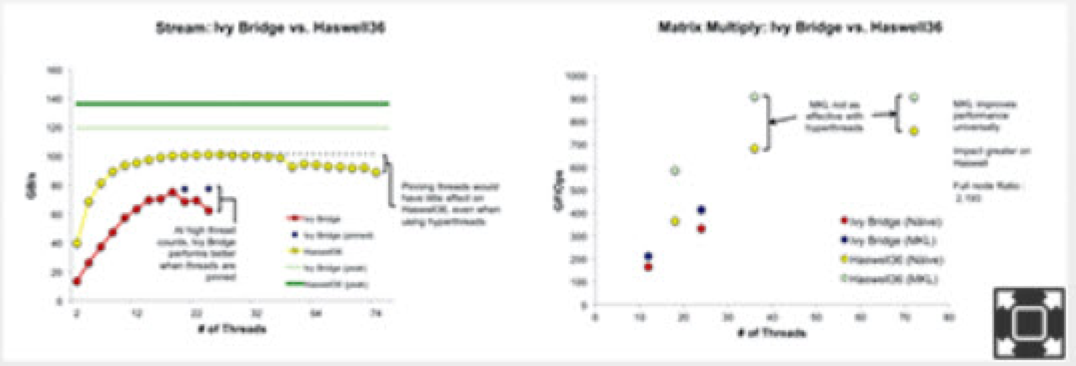
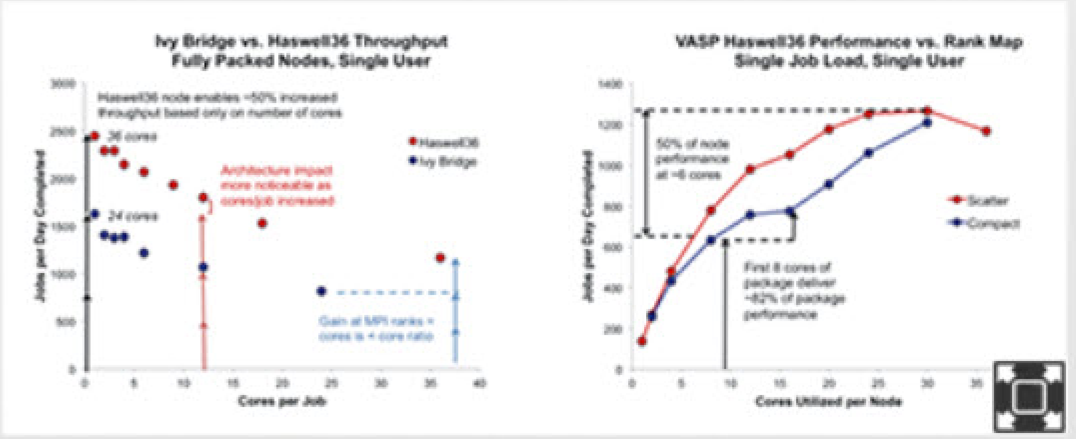
# Impact of Core Density on Parallel Application Performance

C. H. Chang, H. Long, S. Sides, D. Vaidhynathan, W. B. Jones

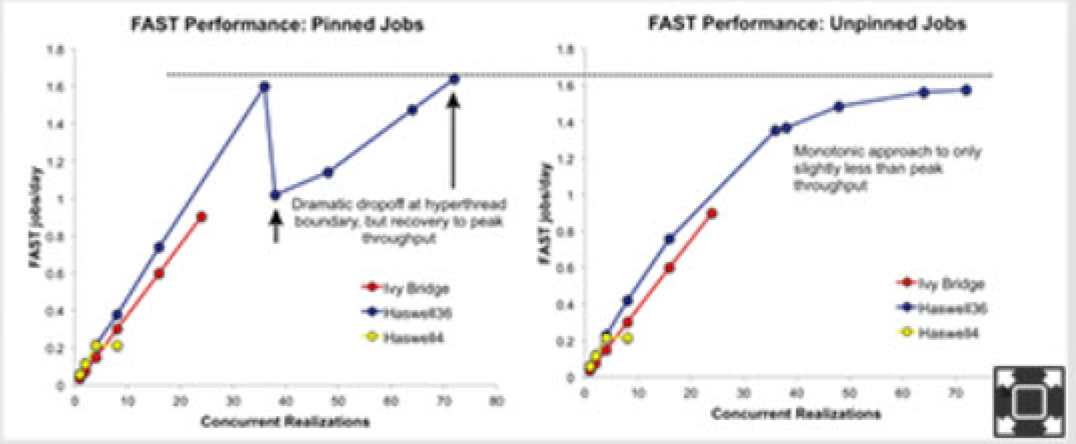
The trend of increasing computing core density in modern processors raises questions about optimal system configuration and the ways to maximize scientific throughput on these architectures. To evaluate the important tradeoffs that users will see with third-party applications, we evaluated the effects of job configuration and use of hyperthreading with two microbenchmarks and several applications that dominate NREL's Peregrine cluster usage. Principal conclusions are (a) in high-throughput situations, placing multiple independent jobs on-node is preferable to serializing highly parallel jobs, (b) hyperthreading can simplify runtime configuration, and can be enabled without negative impact, and (c) balance-of-system is more diagnostic of real-world productivity than peak performance.



Microbenchmarks: On STREAM, pinning threads shows a larger impact on a dual 12-core Ivy Bridge production system than on a test dual 18-core Haswell system. For matrix-multiply, although a simple naïve algorithm performs slightly better, the optimized algorithms in Intel MKL are dramatically better on Haswell. Use of hyperthreads does not increase performance on this 10000 X 10000 test case.



VASP (materials DFT): Optimal throughput on both Ivy Bridge and Haswell was achieved by packing a node with serial jobs. The incremental value per core dropped as parallelism per job was increased. On the Haswell test system, mapping ranks onto a single package showed 82% of achievable performance achieved with 8/18 cores; scattering ranks showed 50% of peak node performance on 6/36 cores.



FAST (turbine CAE): When threads running independent tests were pinned to cores, peak throughput was attained by populating all cores; however, engaging a second thread on even one core lowered throughput dramatically. Leaving threads unpinned allowed a smooth approach to near-peak throughput without added complexity of specifying pinning.

FUNDING & CREDITS

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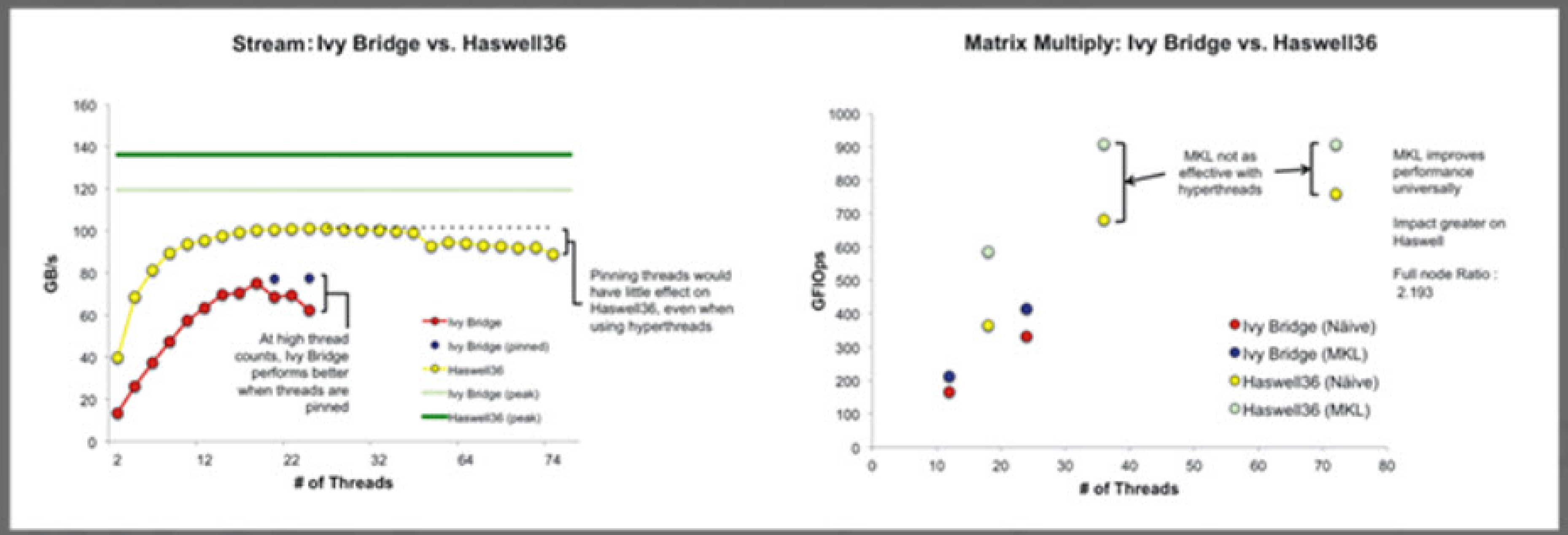


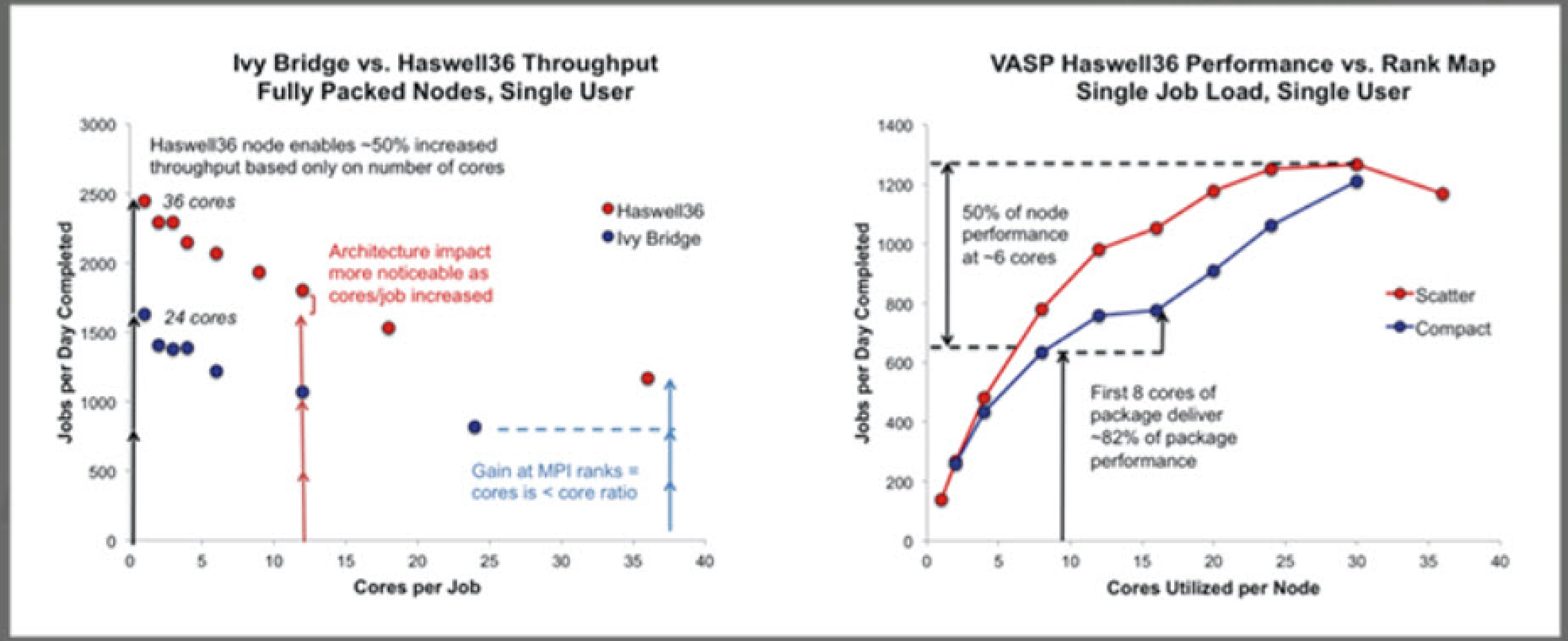


n Parallel

W. B. Jones

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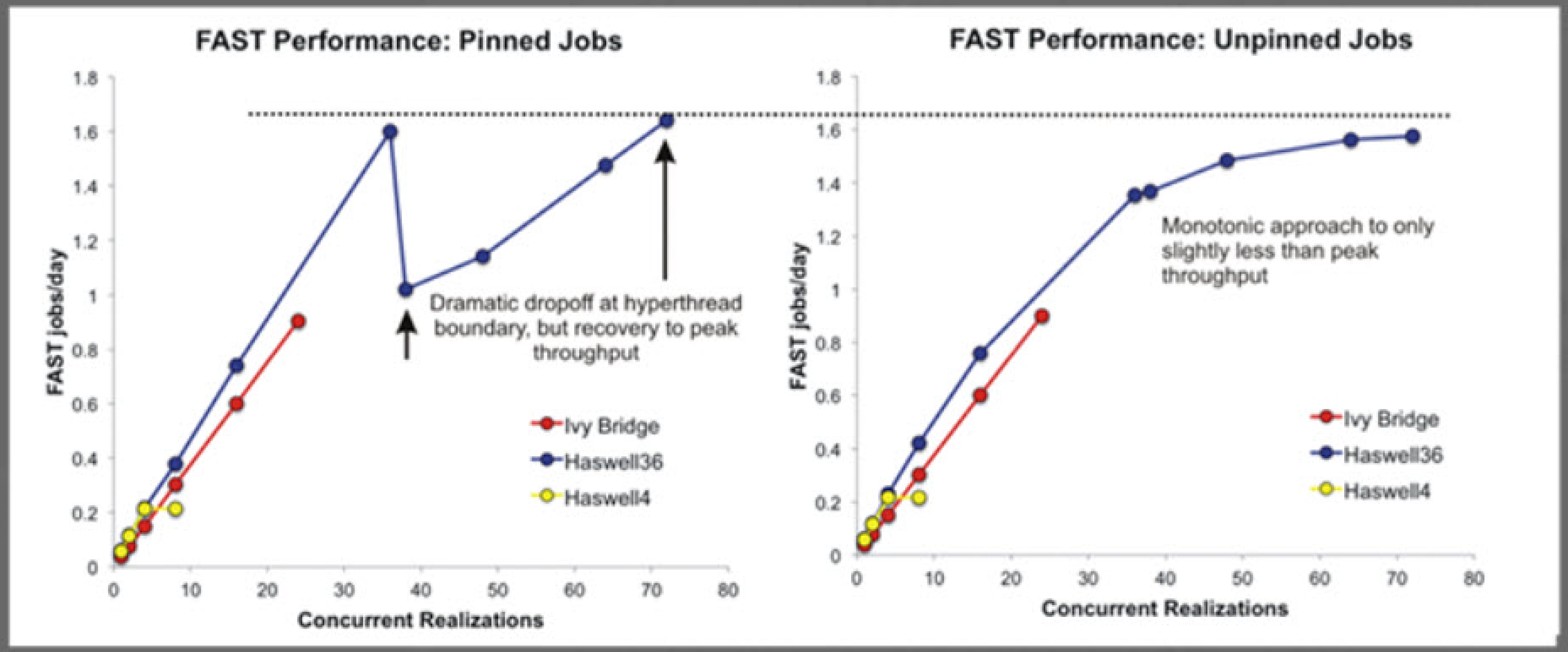


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This work was supported by the U.S. Department of Energy under Contract No. DE-AC36-08GO28308 with the National Renewable Energy Laboratory.


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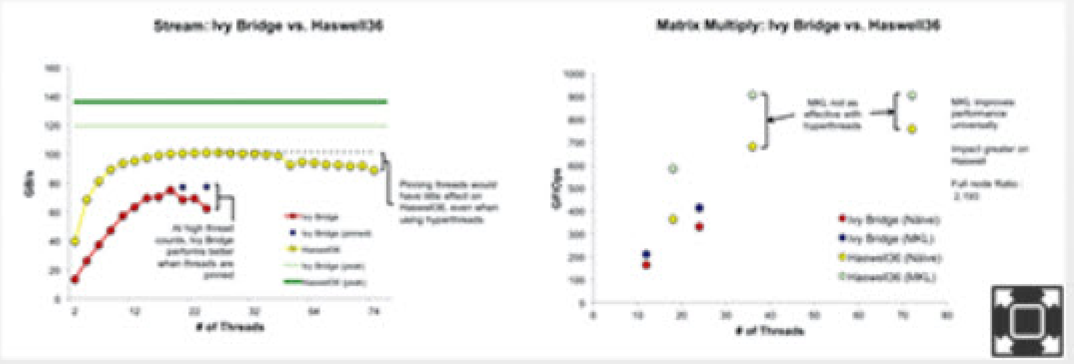

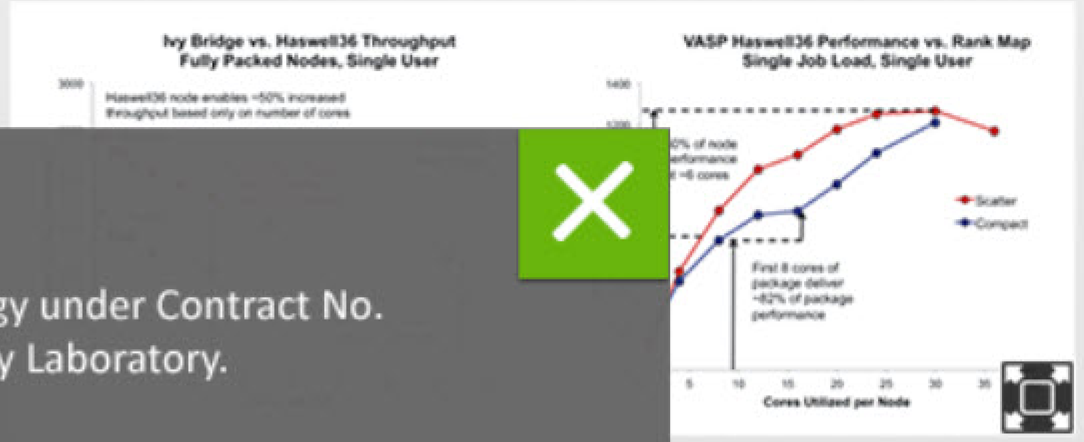

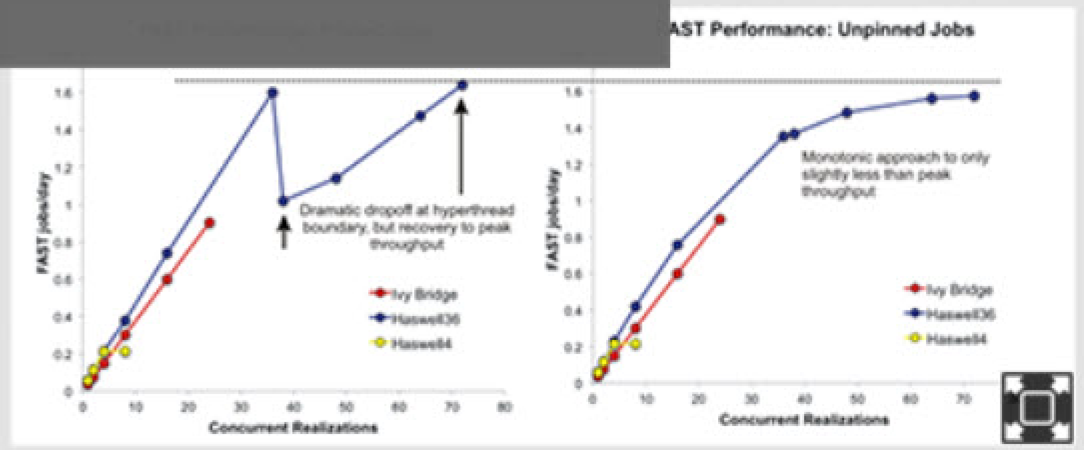

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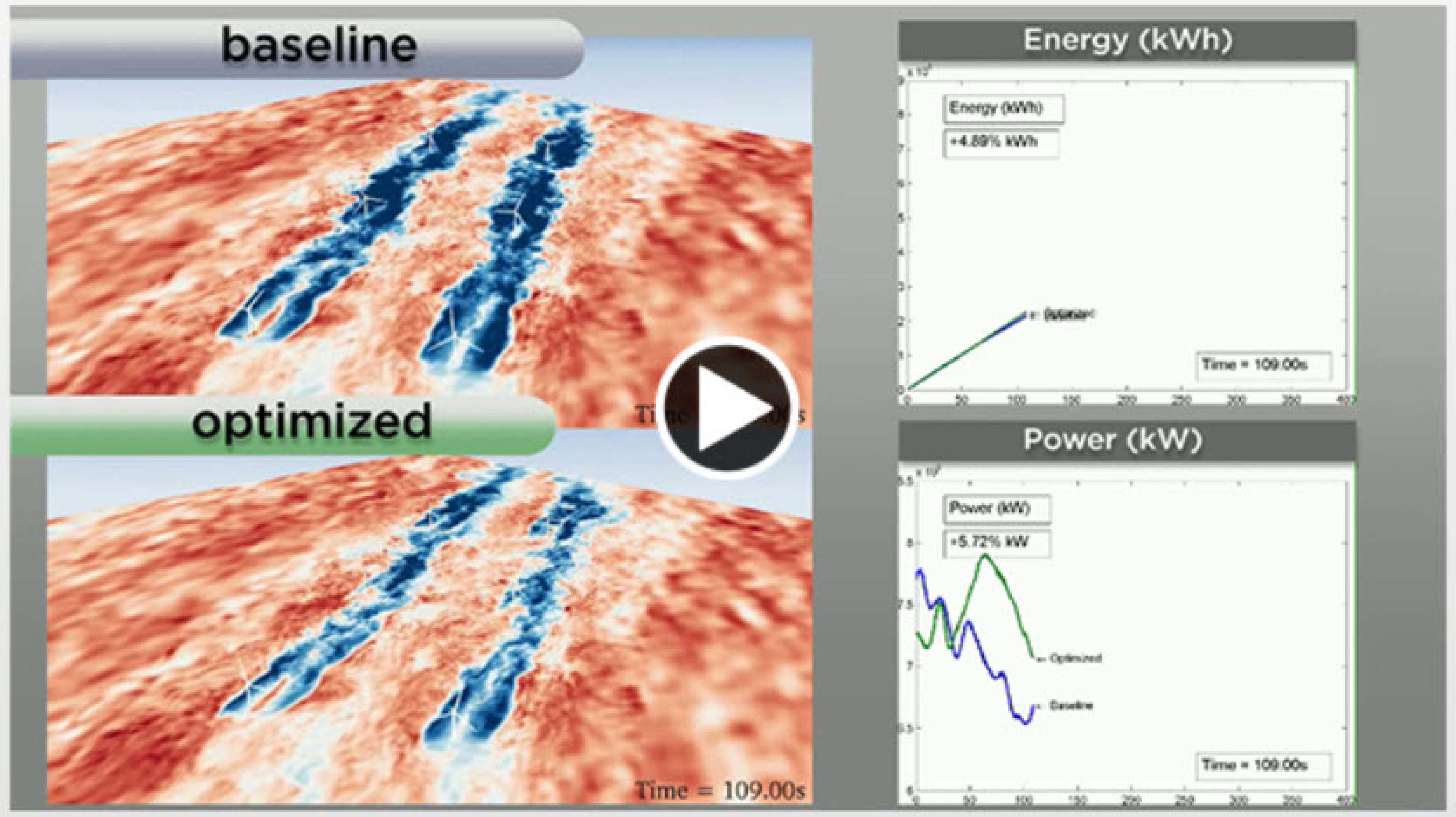
# Development of wind power plant control strategies using SOWFA high-fidelity simulations

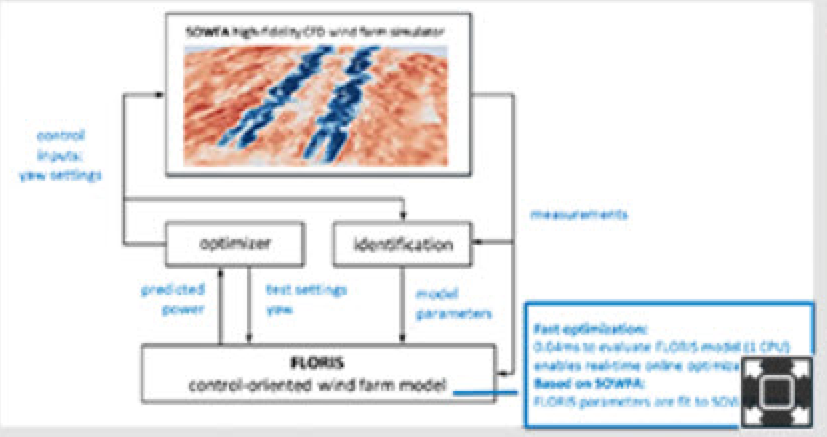
Pieter Gebraad, Paul Fleming, Katherine Dykes

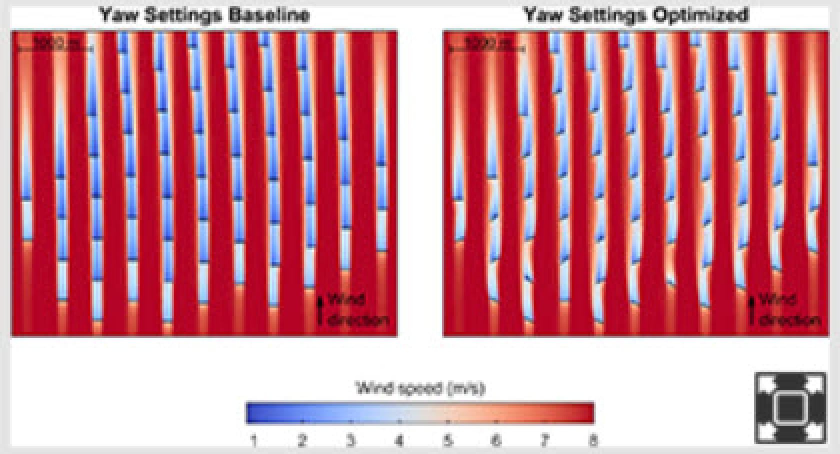
Wind turbines in a wind power plant influence each other's performance through the wake that forms downstream of their rotor. The wake has a reduced wind speed and an increased turbulence. The wakes therefore cause lower energy production and increased loads on downstream turbines.

In high-fidelity CFD simulations of wind plants, with NREL's Simulator fOr Wind Farm Applications (SOWFA), we evaluated the potential of turbine control algorithms to mitigate wake interaction effects. Rotating the rotor around the tower axis (yaw) can be used to redirect the wakes and steer them away from downstream turbines. The power production of the wind plant as a whole is improved by coordinating the yaw control operations across the wind turbines in such a way that wake losses are mitigated.

Using SOWFA, we developed a strategy for optimizing the yaw angles, based on the FLOw Redirection and Induction in Steady-state (FLORIS) engineering model. FLORIS can be used to optimize each of the yaw angles with a strongly reduced computational cost compared to CFD models.




See also:
- P.M.O. Gebraad et al. Wind plant power optimization through yaw control using a parametric model for wake effects - a CFD simulation study. Wind Energy, 2014.
- P.A. Fleming et al. Wind plant system engineering through optimization of layout and yaw control. Wind Energy, 2015.

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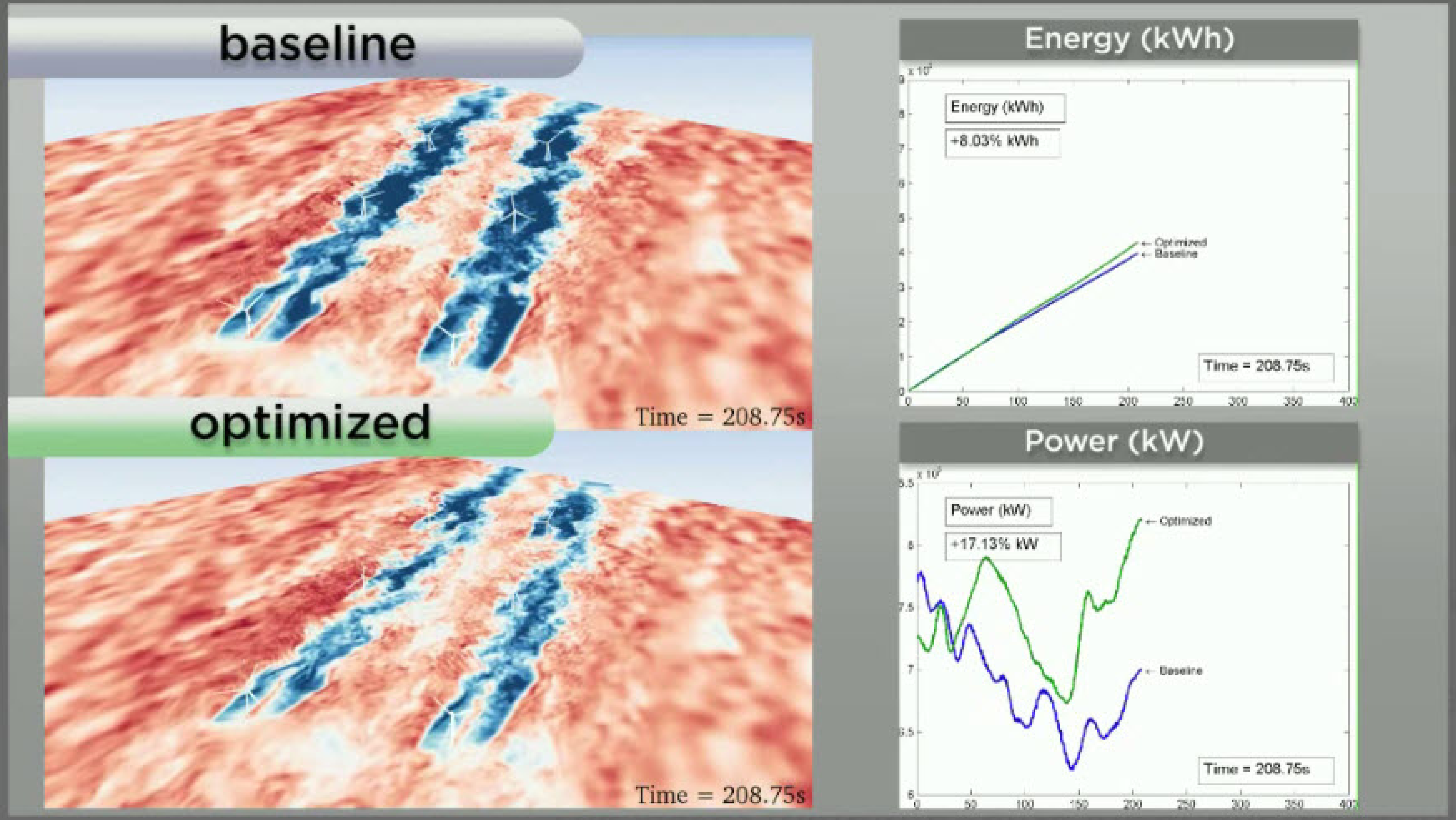
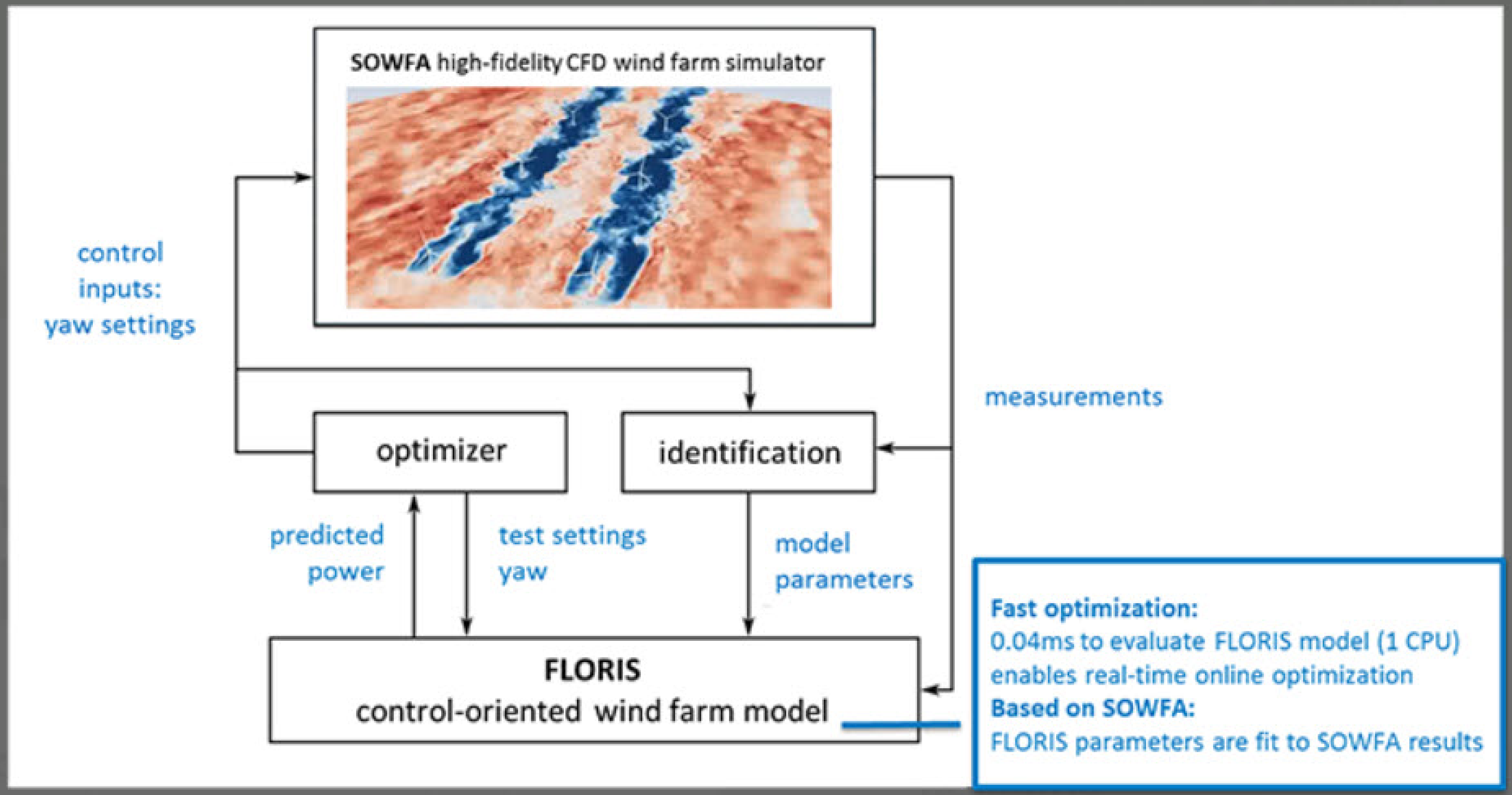



The video above show the flow field in the wind plant as calculated by SOWFA. In the baseline case, the turbine is aligned with the wind direction. In the optimized case, the yaw angles are set so that wake overlap with downstream turbines is reduced. On the right, we see that this optimization leads to an increase in energy production.




The optimal yaw angles in the wind plant simulated in SOWFA are calculated using the FLORIS control-oriented wind plant model. FLORIS is a computationally efficient parametric model for which the parameter values were identified with SOWFA.

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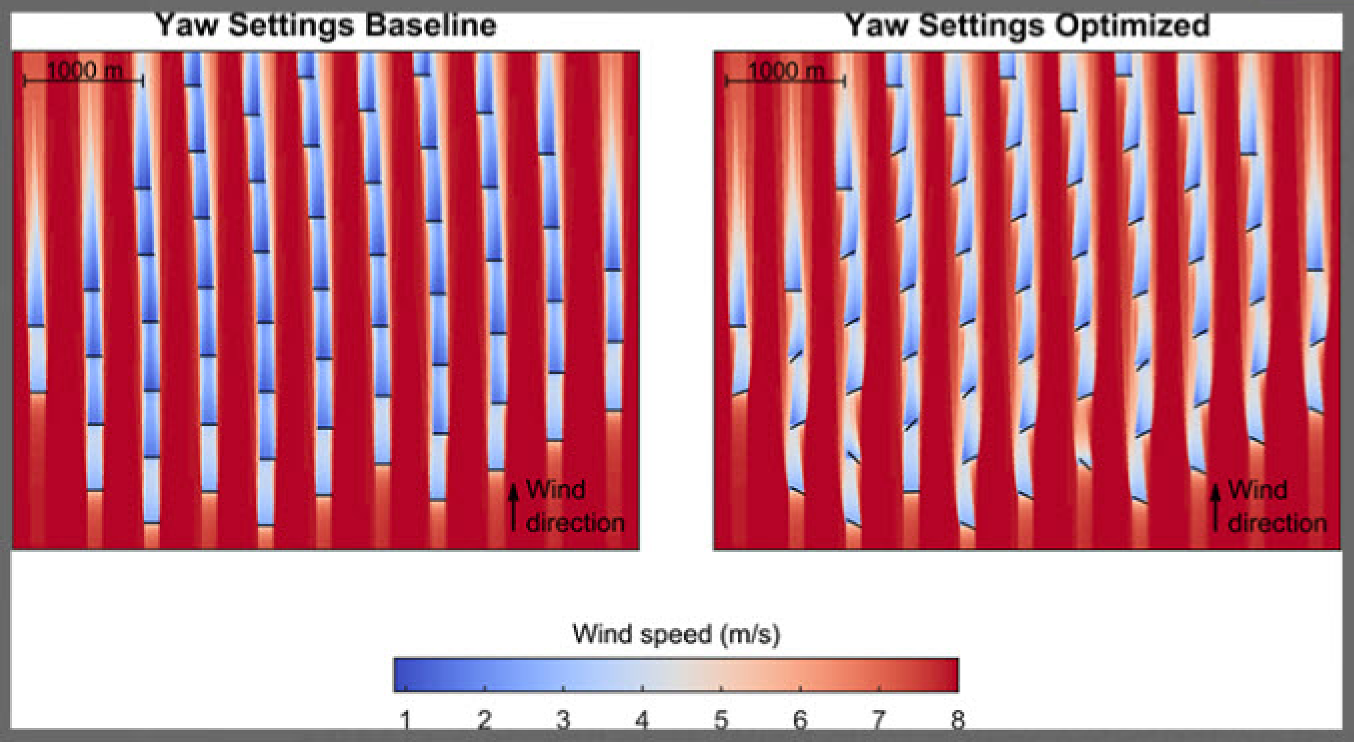
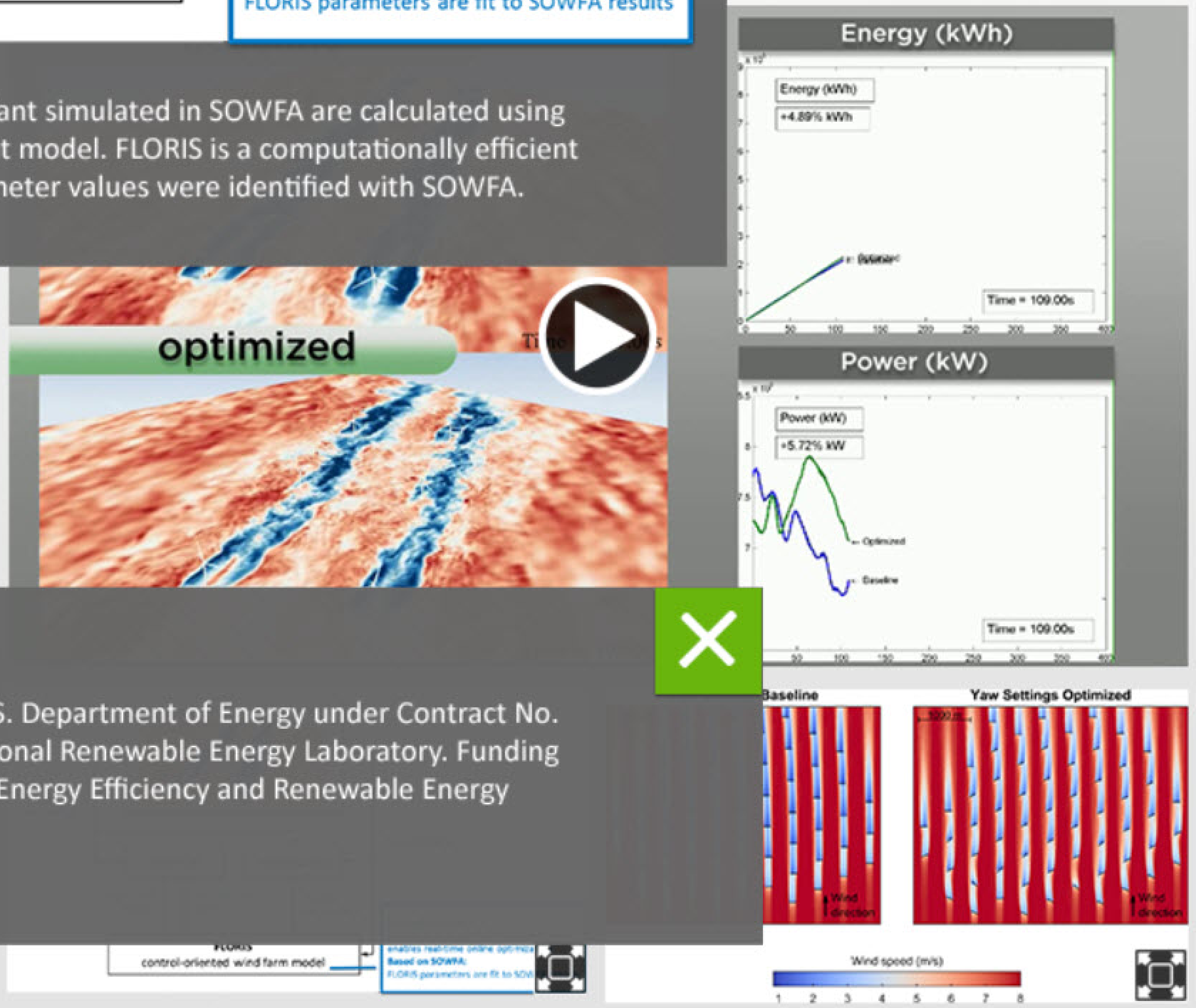



Using the FLORIS model, we can also calculate the optimal yaw angles for larger wind plants, in this case, a wind plant based on the Princess Amalia Wind Park consisting of 60 turbines. For this wind plant, we project that using yaw optimized wake mitigation can increase annual energy production by up to 4%.




This work was supported by the U.S. Department of Energy under Contract No. DE-AC36-08GO28308 with the National Renewable Energy Laboratory. Funding provided by the U.S. DOE Office of Energy Efficiency and Renewable Energy National Wind Technology Center.

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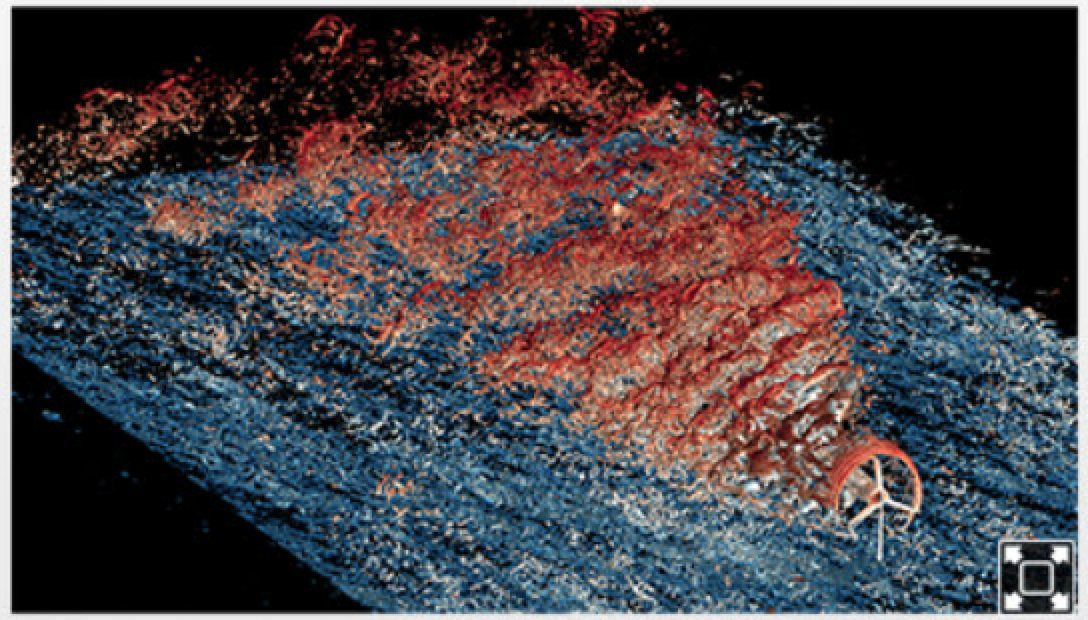
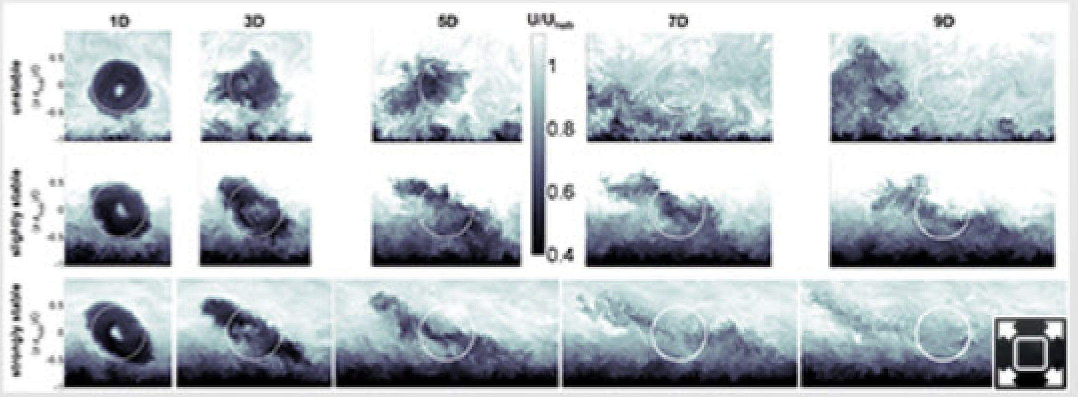
# Large-Eddy Simulations of Wind Turbine Wakes Subject to Different Atmospheric Stabilities

Matthew J. Churchfield, Julie K. Lundquist, Eliot Quon, Sang Less, and Andrew Clifton

Wind turbines create wakes behind them as a result of energy extraction from the wind. Wakes are characterized by reduced wind speed and increased turbulence levels as compared to the undisturbed winds. When turbines are placed near one another, such as in a wind farm, the downstream turbines are often waked by upstream turbines. Waked turbines produce less power and experience increased fatigue-producing mechanical loads. It is, therefore, important to well understand wake behavior.

Wakes are highly impacted by the turbulence in the winds of the atmospheric boundary layer (ABL), which is dependent on the stability of the ABL. The daytime ABL is often unstable, meaning there is near-surface air rising into cooler air above causing turbulence. The night time ABL is often stable because cool near-surface air lies below warm air aloft, which damps turbulence. Stability affects how wakes meander and how they decay. In this study, we perform turbulence-resolving large-eddy simulations of wakes under different atmospheric stabilities. We show that wakes in stable conditions can be much more persistent than wakes in unstable conditions. Stable conditions also often exhibit a large change in wind direction with height, which causes significant wake skewing with downstream distance.





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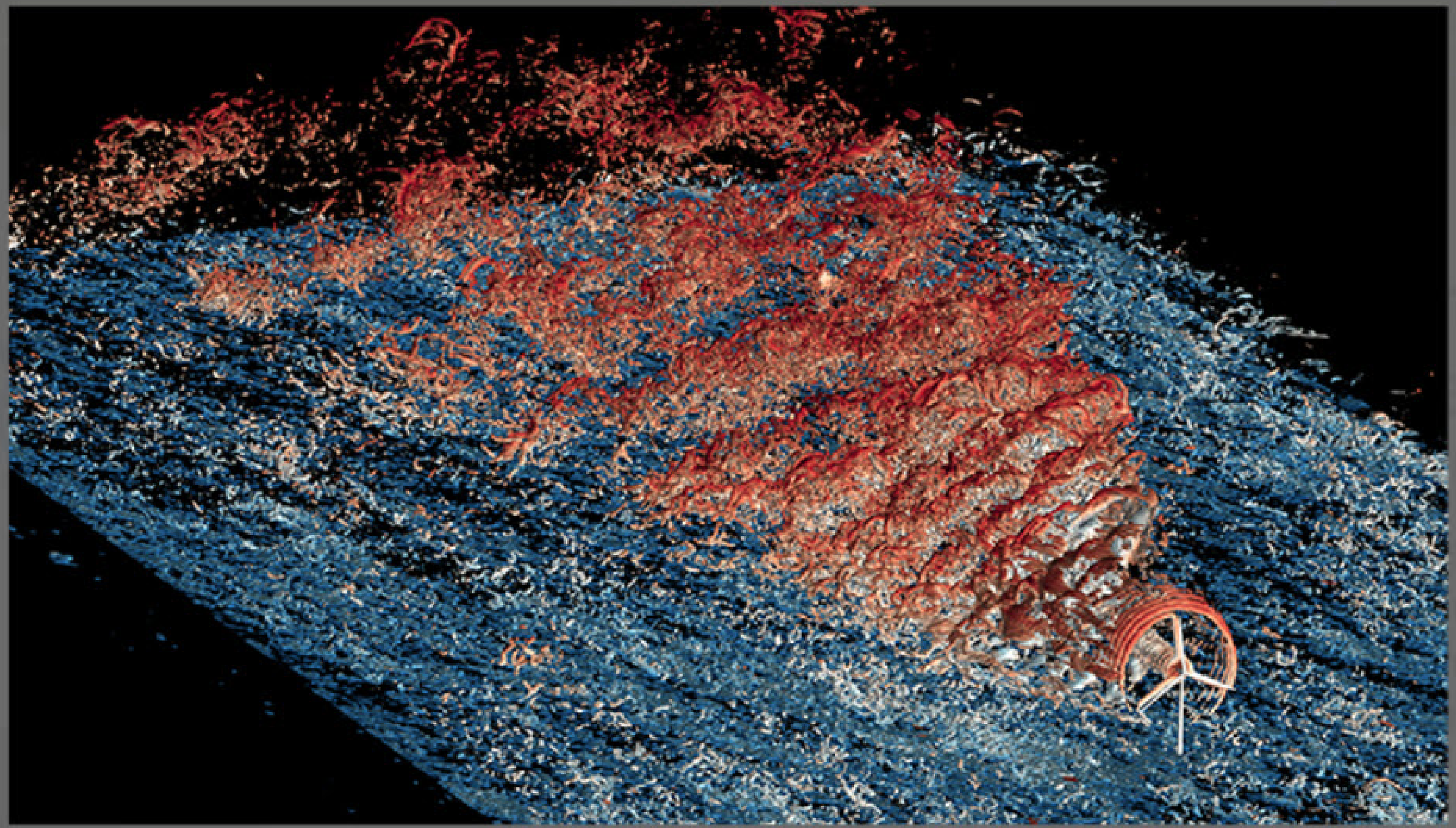
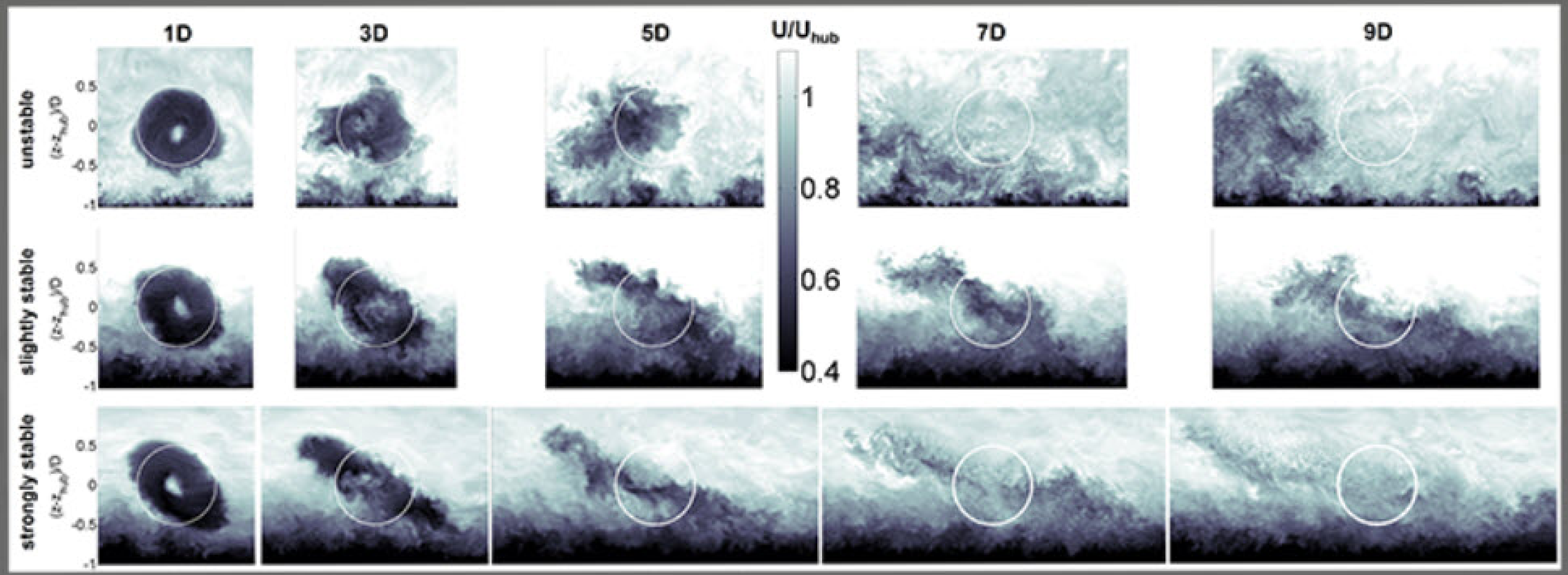


Isosurfaces of vorticity magnitude colored by streamwise velocity (red is higher speed, blue is lower speed) in the wake of the turbine in the strongly stable atmospheric boundary layer. The wake is clearly visible in red.




Contours of instantaneous streamwise velocity in vertical planes perpendicular to the wake at different downstream locations with different atmospheric stability. The size and height of the rotor disk is shown as a white circle.

This work was supported by the U.S. Department of Energy under Contract No. DE-AC36-08GO28308 with the National Renewable Energy Laboratory. Funding for the work was provided by the DOE Office of Energy Efficiency and Renewable Energy, Wind and Water Power Technologies Office.